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THE GIPSY MOTH AND THE BROWN-TAIL MOTH AND THEIR CONTROL

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In Charge of Gipsy Moth and Brown-tail Moth Investigations



Female gipsy moths depositing eggs on tree trunk

FARMERS' BULLETIN 845

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology

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THE GIPSY MOTH and the brown-tail moth are among the most serious and destructive of the insects injuring tree growth that have been introduced into the United States.

About one-third of the area of New England is now infested with these pests.

Marked progress in checking their spread has resulted from the field and quarantine work now being carried on and from the introduction of parasites and natural enemies, and the increase in the diseases that attack them has served to lessen the damage.

The work of combating these insects is being carried on by each of the New England States and by the United States Bureau of Entomology.

Hand methods generally employed against the gipsy moth are treatment of the egg clusters with creosote, banding the trees with burlap or a suitable tree-banding material, and spraying. These are described on pages 15-19.

Hand methods applicable against the brown-tail moth consist in cutting off and burning the winter webs before the caterpillars emerge in April and spraying with arsenate of lead, as described on pages 14-15, before the middle of August. Where the infestation is very slight the cutting and burning of the webs will be more satisfactory than spraying.

Orchards can be protected fully from these pests by a system of management that will cost very little in addition to the expense required for protection against other orchard insects. See pages 19-21.

The expense of caring for infested city and park trees is somewhat greater than for orchards, but practical measures can be adopted, as shown on page 21, and their cost will not be prohibitive.

The control of the gipsy moth and the brown-tail moth in forests is extremely difficult, owing to the relatively small amount of money that any owner can afford to expend in protecting his woodland. He should accept the advice of a State, local, or Federal official familiar with these insects and their control, who, after an examination, would be able to suggest the measures most applicable in the particular case. The general principles involved in woodland control of the brown-tail moth are explained on page 24, and those for the gipsy moth on pages 22-24.

THE GIPSY MOTH¹ AND THE BROWN-TAIL MOTH² AND THEIR CONTROL.

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IN 1869 a number of egg clusters of the gipsy moth, an insect pest destructive in Europe, were brought from France to Medford, Mass., by a naturalist who was carrying on experimental work with insects. Later in the season some of the caterpillars escaped, and although none was found in the vicinity during the next few years, enough specimens survived to enable the species to establish itself. In the summer of 1889 this insect became so abundant that fruit and shade trees in the neighborhood were completely defoliated, and the caterpillars swarmed over the trees and into the houses and became a serious nuisance. Valuable trees were lost and property values in that section depreciated.

For about 10 years effective work against the gipsy moth was carried on by the State of Massachusetts, and during this period the insect was kept under control. The work was discontinued in 1900, but the species had become so abundant and had caused such widespread injury by 1905 that systematic work was renewed by the State for the protection of tree growth in the infested area. This work has been continued up to the present time, and as the insect has spread to other New England States it has become necessary to institute more extensive control measures.

In 1906, after the gipsy moth had become established in New Hampshire and Rhode Island, as well as in Massachusetts, an appro-

¹ *Porthetria dispar* L.

² *Euproctis chrysorrhoea* L.

priation was made by Congress for suppressing it, and the Secretary of Agriculture was authorized to take all possible measures to

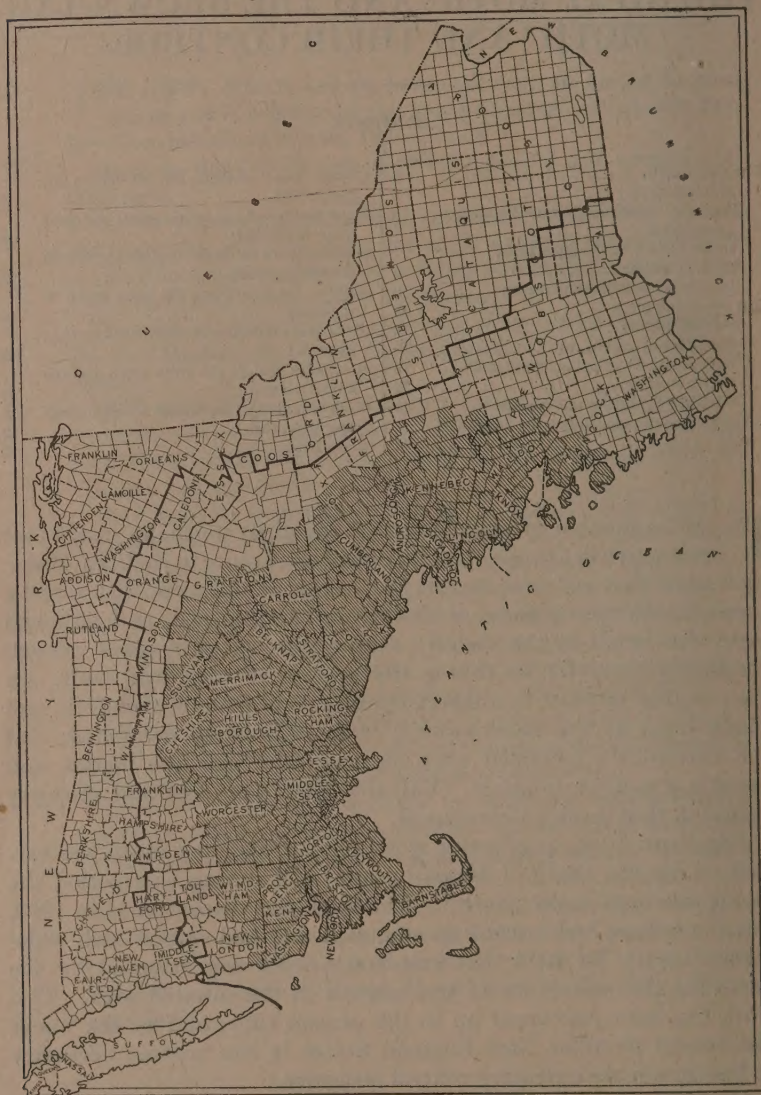


FIG. 1.—Map showing area infested by and quarantined for the gipsy moth and the brown-tail moth in New England, 1917. Shaded area infested by the gipsy moth; area east of heavy line infested by the brown-tail moth.

prevent its spread. Since that time work has been carried on each year. The area now known to be infested is shown in figure 1.

The brown-tail moth was first found in the United States in Somerville, Mass., during the summer of 1897 and was undoubtedly introduced several seasons before that time on imported nursery stock. The work of preventing damage by this insect was undertaken by the State of Massachusetts soon after the pest was discovered. This species occurs in many sections of Europe and often is seriously injurious. It spreads rapidly because the females are able to fly long distances. Figure 1 shows the area in New England which is now infested by the brown-tail moth. Suppressive measures by the New England States and by the Federal Government have been directed against this insect as well as against the gipsy moth.

This bulletin describes briefly the seasonal history and habits of these two species and suggests the best methods for their control, determined and adopted as a result of many extensive experiments.

THE GIPSY MOTH.

SEASONAL HISTORY.

(Fig. 2.)

In the course of its life the gipsy moth passes through four stages—namely, the egg, the larva or caterpillar, the pupa or resting stage, and the adult or moth.

The eggs.—The female gipsy moth deposits a cluster containing 400 eggs or more, which she covers with buff-colored hairs. Most of the egg clusters are laid during the month of July and hatch about the time the leaves begin to appear the following spring. They are deposited on the underside of branches of trees, on tree trunks, under loose bark, or in cavities in the trunks or branches, and are sometimes placed on stones or rubbish and in a variety of situations where they are concealed from view. As the female moth does not fly, egg clusters are seldom found far from the food plant upon which the caterpillars developed.

The larvæ.—The newly-hatched larvæ feed on the opening leaves, making small perforations. They grow rapidly and become full fed early in July. During this period they molt five or six times, and as they increase in size a larger proportion of the foliage is eaten, so that if the infestation is severe, trees may be stripped of foliage completely before the end of June.

The pupæ.—When full grown the caterpillars shed their skin and transform to pupæ, which are chestnut brown in color and provided with tufts of yellow hairs. They remain in this dormant stage for about 10 days, after which the adult insects emerge.

The adults.—The male moth is dark brown, with black wing markings, and flies well. The female is white, with black markings on the wings, and because of the weight of the abdomen does not fly. After mating the females begin depositing eggs.

MEANS BY WHICH THE GIPSY MOTH IS SPREAD.

Egg clusters of the gipsy moth that are deposited on trees, lumber, stone, or other products that are likely to be shipped may be carried long distances and cause the establishment of new colonies of the insect. Spread in this way is prevented by inspection of such products before they are shipped. Caterpillars of this insect may be spread for limited distances by carriage on moving objects, such as



FIG. 2.—Different stages of the gipsy moth (*Porthetria dispar*): Egg mass on center of twig; female moth ovipositing just below; female moth below, at left, enlarged; male moth, somewhat reduced, immediately above; female moth immediately above, somewhat reduced; male moth with wings folded in upper left; male chrysalis at right of this; female chrysalis again at right; larva at center.

trains, horse-drawn vehicles, or automobiles. The danger of such spread is very limited if the roadways are kept free from severe infestation, and under present conditions in the infested territory danger of spread in this way is not great. New colonies are started principally by the spread of newly hatched caterpillars. Experiments have shown that under favorable conditions these caterpillars may be blown by the wind. The temperature must be high enough for the caterpillars to be active and the stronger the wind the greater the probability of their being carried long distances. It has been demonstrated that caterpillars have been carried more than 20 miles in this way, and specimens have been caught in the air 50 feet above the ground, although probably they are carried much higher than this. It is necessary for the temperature to range above 65° F. and for the wind velocity to be 8 miles or more per hour, in order that wind spread of small caterpillars may result.

FOOD PLANTS.

The food plants most favored by the gipsy moth are the apple, the different species of oak, gray birch, alder, and willow. In cases of bad infestation nearly all deciduous trees are injured to a greater or less extent, with the exception of ash. Hickory is not a favored food plant, although the foliage occasionally shows severe feeding. Chestnut will not support the gipsy moth when the caterpillars are in the first stage, and pine will not support the first two stages; but if other food plants are present severe injury may result from feeding by the larger caterpillars. Beech is sometimes fed upon freely, and occasionally the trees are defoliated; and the same is true of poplar.

INJURY CAUSED BY THE GIPSY MOTH.

Unless reduced in numbers by natural enemies, or by the application of control measures, the gipsy moth is capable of causing enormous injury to tree growth. In the area in New England which has suffered most from this insect, thousands of trees are dead as a result of defoliation. (See fig. 3.) Many areas were cut before the trees were mature and the wood sold at a loss on account of damage caused by this insect. Apple and oak have been injured most, but pine and other coniferous trees mixed with deciduous growth have suffered severely.

It is undoubtedly true that many oak trees which have been weakened severely as a result of defoliation by the gipsy moth and the brown-tail moth have failed to recover because of the attacks of certain wood-boring insects. The species which has caused most damage in this way is a beetle¹ known as the two-lined chestnut borer, the larva of which feeds beneath the bark of injured trees.

¹ *Agrilus bilineatus* Weber.

NATIVE ENEMIES.

Few insect enemies of the gipsy moth native to New England cause any noticeable reduction in its numbers. This is shown by the fact that between the years 1900 and 1905, when no systematic effort was made to suppress the insect, alarming injury resulted, and native

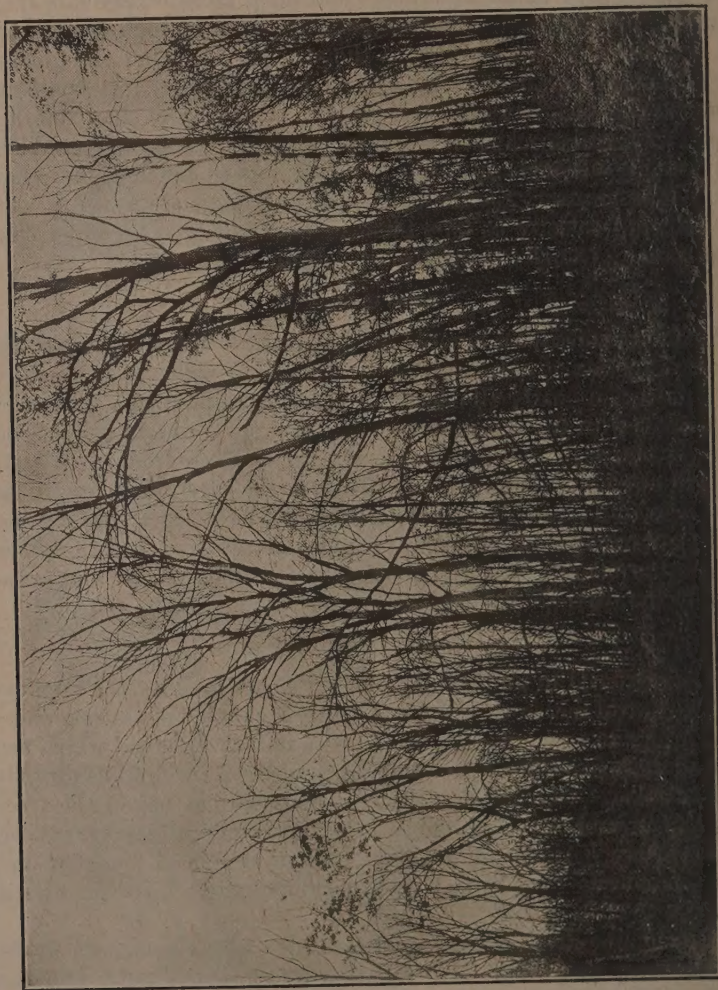


FIG. 3.—Dead and defoliated woodland resulting from gipsy-moth attack.

insect enemies did not increase to any marked degree. The same is true of the work of native insectivorous birds. While they undoubtedly feed to some extent on gipsy-moth caterpillars, there is no case on record where they have been able to control the species. The

wilt disease, however, which possibly may have occurred in this country for many years, has become sufficiently prevalent to be a prominent factor in natural control.

INTRODUCED PARASITES AND ENEMIES.

In 1905 an effort was made by the State of Massachusetts, in cooperation with the Bureau of Entomology, United States Department of Agriculture, to introduce the parasites and natural enemies of the gipsy moth from its native home in Europe and Japan. Since that time a large amount of parasitized material has been received and as a result several natural enemies have become firmly established in this country and are assisting in bringing about the control of the species. The enemies which have become established and are at present destroying the largest number of gipsy-moth caterpillars and pupæ are a beetle,¹ a tachinid fly,² which is also a parasite of the brown-tail moth and attacks many native injurious caterpillars; and a minute four-winged wasplike parasite,³ which attacks small gipsy-moth and small brown-tail moth caterpillars. Two tiny parasites of the eggs, one of which⁴ was imported from Japan and the other⁵ secured from Europe, have also been colonized in a portion of the infested area and are valuable additions to the natural enemies of this insect. Several other parasites have been introduced and are established in this country, but they have not increased sufficiently to be classed as important factors in gipsy-moth control.

The work of the natural enemies of the gipsy moth, including the imported parasites, the *Calosoma* beetle, and the wilt disease, has served greatly to reduce the numbers of the insect in many badly infested localities. This is particularly true in the region which has been infested longest, and it is hoped that when these enemies of the moth have become established in larger numbers over the entire infested territory the insect will be much less a destructive factor than it is at present. Colonization of most of these species has been carried on throughout the entire area but much remains to be done in colonizing the egg parasites. The records at the gipsy moth laboratory at Melrose Highlands, Mass., indicate that all of the species of insect parasites mentioned have been gradually increasing in the field during the past few years and the results of their work are very noticeable in certain restricted areas. Until these natural enemies become more abundant than they are at present throughout the entire infested territory it will be necessary to employ the most effective mechanical methods for restricting the spread and curtailing the increase of this species.

¹ *Calosoma sycophanta* L.

² *Apanteles lacticolor* Vier.

³ *Anastatus bifasciatus* Fonsc.

⁴ *Compsilura concinnata* Meig. ⁵ *Schedius kuanæ* How.

THE BROWN-TAIL MOTH.

SEASONAL HISTORY.

(Fig. 4.)

As is the case with all other moths, the brown-tail moth in its development is first an egg, then a larva or caterpillar, then a pupa, and finally an adult moth.

The eggs.—The female brown-tail moth deposits a small cluster of eggs on the underside of a leaf. These eggs usually are laid in July and are covered with brown hairs taken from the body of the female. Hatching begins about the 15th of August.

The larvæ.—The newly hatched larvæ of this insect feed on the epidermis of the leaf and after molting once or twice begin to construct a winter web. This is made by drawing together several terminal leaves and securely fastening them by silk which is secreted by the caterpillars. The larvæ from one or more egg clusters live and feed in common, and as cold weather approaches they retire to the web, in which they remain during the winter. In the spring these larvæ leave the web as soon as the buds begin to develop and feed upon the bud scales and small leaflets. They become full-grown about the middle of June.

The pupæ.—After the caterpillars finish feeding they spin loose silken cocoons and pupate within them. These cocoons sometimes are constructed separately, but in many cases large numbers of them are spun in a single mass. About two weeks are spent in the pupa state.

The adults.—Emergence of the moth usually begins the first week in July. The adult brown-tail moth is pure white. The abdomen of the female is much larger than that of the male, but in both sexes the tip of the abdomen is covered with dark-brown hairs. These moths are attracted to strong light, such as electric arc lights, and as they fly at night it is often possible to secure many specimens around the arc lights in cities and towns during the first half of the month of July.

FOOD PLANTS.

The caterpillars of the brown-tail moth commonly feed on apple, pear, plum, oak, and willow, and sometimes they are found in considerable numbers on elm, maple, and rose and in smaller numbers on other common deciduous trees and shrubs. They never attack conifers and are seldom found on hickory, ash, chestnut, or birch.

INJURY CAUSED BY THE BROWN-TAIL MOTH.

The principal injury caused by the brown-tail moth is due to the feeding habits of the larvæ in the spring. If the infestation is bad, the caterpillars often are numerous enough to devour the leaves as

fast as the trees are able to develop them. As the webs are made on the terminals, the growth of the trees often is checked severely. In heavy infestations trees may be stripped completely (figs. 5, 6), but as the larvæ become full-grown during the first part of June, the trees usually have an opportunity to refoliate before midsummer. The young larvæ that hatch in August frequently skeletonize the leaves

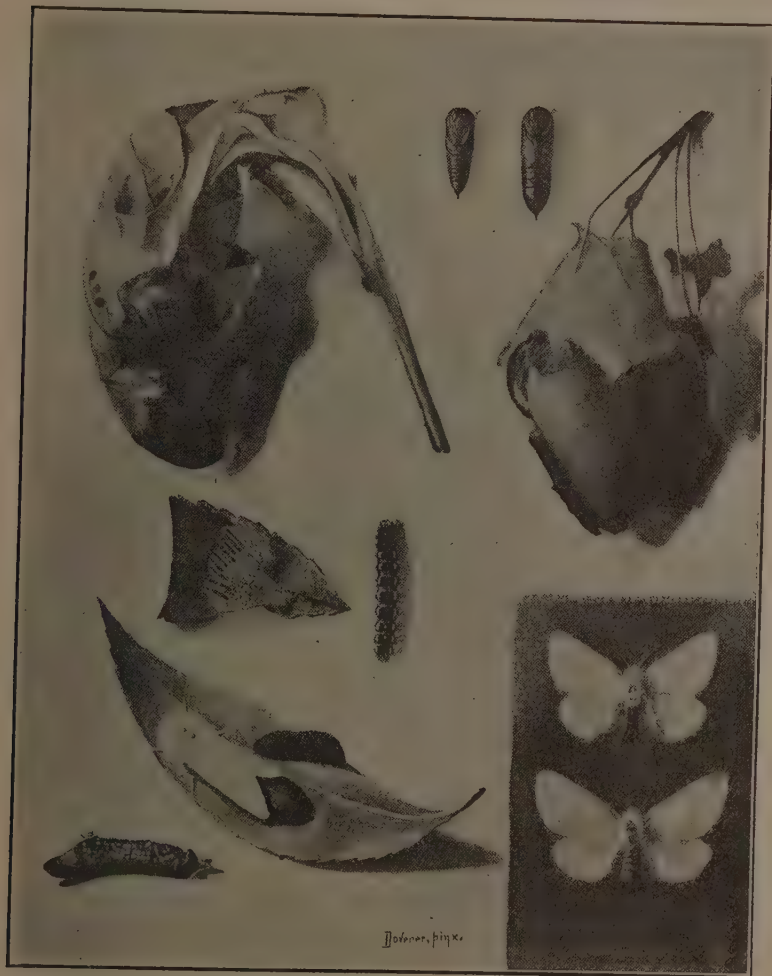


FIG. 4.—Different stages of the brown-tail moth (*Euproctis chrysorrhoea*): Winter nest at upper left; male and female adults, lower right; cocoon in leaves, upper right; male and female chrysalides above, male at left; full-grown larva in center, somewhat reduced; young larvæ at its left; egg mass removed from leaf, showing single eggs, at lower left; female ovipositing on leaf; egg mass also on same leaf.

to a considerable extent. This does not damage the trees seriously, as the growing period for the season is nearly completed.

The bodies of the caterpillars of the brown-tail moth are provided with poisonous hairs. A microscopic examination of these hairs shows that the edges are barbed in such a way that when they come in contact with the human skin and are pressed into the flesh, intense irritation is caused. These hairs are also hollow and contain a poisonous substance which acts on the blood corpuscles. This causes serious poisoning and severe irritation accompanied with external swelling and is known as the brown-tail rash. Persons differ considerably in their susceptibility to this poison, but many cases are reported each year in the infested region, most of which are more



FIG. 5.—Apple trees stripped by brown-tail moth caterpillars. Note old winter webs at tops of trees.

serious than those of ivy poisoning. Many camps and summer cottages, particularly in wooded areas, can not be occupied with any comfort during the early summer on account of the poisoning resulting from these caterpillars. If clothing is hung on the line near badly infested trees, the hairs frequently find lodgment and are brought into the houses, and later severe poisoning may result.

NATIVE ENEMIES.

One of the most important natural enemies of the brown-tail moth is a fungous disease,¹ which attacks the caterpillars, particularly in the spring. It was first reported in this country by Dr. Roland

¹ *Entomophthora aulicæ*.

Thaxter in 1888. Like all diseases of this nature, the benefit derived from it is regulated largely by favorable or unfavorable weather conditions. This fungus sometimes works to a slight degree on the small caterpillars in the fall, and in some instances it is found in the winter webs. As a rule, however, the greatest mortality of caterpillars takes place in the spring, when they are nearly full-grown, and the pupæ of the moth, under the most favorable conditions,

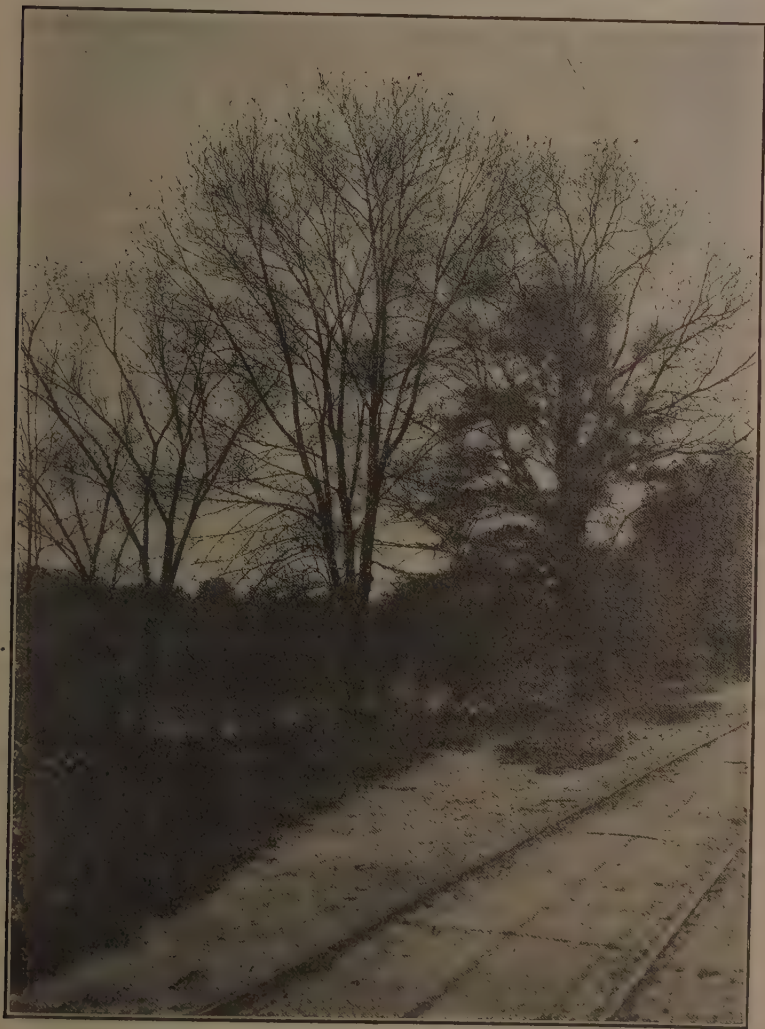


FIG. 6.—Red oak trees stripped by brown-tail moth caterpillars. Note old winter webs at tops of trees.

may be almost completely exterminated. Native parasites and predacious insects have done very little to check the increase of the brown-tail moth.

INTRODUCED PARASITES AND ENEMIES.

The parasites and enemies already mentioned as being particularly valuable for their work in destroying the gipsy moth, with the exception of the egg parasites, also attack the brown-tail moth. The *Calosoma* beetle¹ and its larvæ do valuable work each year in destroying brown-tail caterpillars and pupæ, and the insect parasites also attack this species in considerable numbers. Another imported parasite² has become established in this country and is doing excellent work. It attacks the brown-tail moth caterpillars, but not those of the gipsy moth.

Throughout the infested territory a marked decrease in the number of moths has been noted during the last two or three years. The work of the parasites has been a very important factor in this connection. In some parts of the infested territory the mortality among the caterpillars in the brown-tail webs has been very high during the winter.

HAND METHODS FOR CONTROLLING THE BROWN-TAIL MOTH.

The brown-tail moth can be controlled by cutting off the winter webs and burning them before the caterpillars begin to emerge in April. These webs should be destroyed by fire, for if they are simply cut from the tree and left on the ground the caterpillars will emerge and no benefit will result from the work which has been done.

In orchard practice it is sometimes inadvisable to cut the winter webs, for where an infestation is bad it is likely to leave a poorly shaped tree. Spraying in the spring is not a satisfactory remedy unless the infestation is very light, because the caterpillars, when they occur in large numbers, do not allow the tree to put out sufficient foliage to hold the spray material. The most effective method is to spray the trees before the middle of August, using from 6 to 10 pounds of arsenate of lead to 100 gallons of water. Before spraying operations of this sort are attempted care should be taken to determine whether the trees are well infested with egg masses of the brown-tail moth, for if the infestation is very slight it will be more satisfactory to cut and destroy the webs. If the infestation warrants, both shade, ornamental, and fruit trees may be sprayed to advantage at this time. Caution should be used, however, in spraying fruit trees, particularly if early fall varieties are to be treated. If this is to be done, a somewhat weaker spray solution may be used, provided it is applied as soon as the caterpillars begin to hatch. The

¹ *Calosoma sycophanta* L.

² *Metcorus versicolor* Wesm.

foliage should be treated thoroughly, particularly the terminal shoots, and as much care as possible should be exercised not to cover the fruit. Late fall or winter varieties of fruit may be sprayed in August with arsenate of lead, using 6 pounds to 100 gallons of water, and although an occasional spot may be found on the fruit at the time of picking, no injury will result from it. In cases where only a few choice fruit trees are sprayed it is practicable to wipe the fruit before packing for sale; but this will not be necessary if care is taken to treat the terminal growth of the trees, as this is where the bulk of the egg clusters is deposited.

GENERAL HAND METHODS FOR CONTROLLING THE GIPSY MOTH.

Creosote.—One of the best methods of controlling the gipsy moth is to treat the egg clusters of the insect between August 1 and April 1 with creosote, to which a small amount of lampblack has been added. This material is sold by dealers in the infested region under the name of gipsy-moth creosote. It is applied with a brush, and leaves a black residue on the clusters treated. Creosote may be obtained in small quantities from nearly all the large hardware or seed stores in the infested district.

Burlap bands.—Gipsy-moth caterpillars usually seek shelter during hot, sunny days, and if a band of burlap is attached to a tree, large numbers of them will crawl beneath it, where they may be crushed each day. Ordinarily a strip of burlap about 8 inches wide is placed loosely around a tree trunk and a piece of twine passed around the center and tied to hold it in place. After this is done the top part of the burlap is folded down so that a double shelter is made beneath it. The use of burlap bands has been discontinued during the last few years, owing to the expense involved and because of the fact that if the burlaps are applied early in the season, before the brown-tail caterpillars have pupated, an excellent place is furnished for these poisonous caterpillars to make their cocoons (see fig. 7), and severe poisoning results to the workmen. If this method is to be used at all, the burlap should not be attached to the trees until after June 15, when most of the brown-tail moth caterpillars will have pupated.

Sticky bands.—Bands of a widely known sticky substance for use in banding trees, which may be obtained on the market, may be used on tree trunks after the bark has been scraped so that the material can be applied evenly in a thin layer with a paddle. The purpose of this band is to prevent caterpillars from ascending the trees, and if the egg clusters previously have been treated, this is a very effective measure. It is necessary every week or 10 days during the caterpillar season to run a comb or other similar implement around the band in order to prevent hardening of the surface and to bring up fresh, sticky material from the part of the band near the bark. (See

fig. 8.) Placing these bands on the trees prevents the caterpillars from reaching the foliage; and as the caterpillars usually mass in large numbers beneath the bands, conditions are favorable for the development of wilt disease, and the caterpillars often die in large numbers from this cause and from starvation.



FIG. 7.—Burlap band on tree. The caterpillars beneath it are nearly all those of the brown-tail moth.

Use of tree-banding material.—A new material for banding trees has been prepared and tested by the Bureau of Entomology in cooperation with the Bureau of Chemistry. It is black and of a greasy nature and is applied to the trees with a special "gun"

designed for the purpose. (Fig. 9.) A thick, narrow band is left on the tree trunk, preventing the caterpillars from reaching the foliage. This material is cheap and effective and is more easily applied than is the sticky substance mentioned in the last paragraph, because it is not necessary to scrape the trees before it is put on.

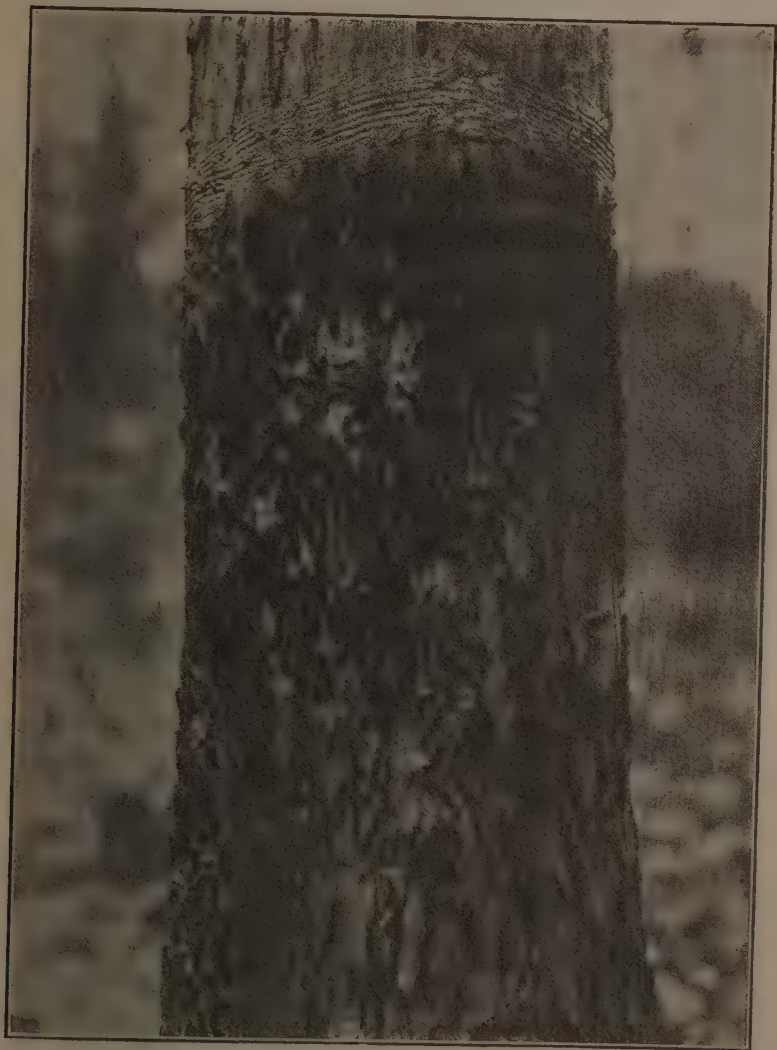


FIG. 8.—Band of sticky material. Note that the enormous numbers of gipsy-moth caterpillars are below the band, but none are above it.

Spraying.—The most effective spray for the gipsy moth is arsenate of lead paste applied to the foliage at the rate of 10 pounds to 100 gallons of water. It is necessary that the treatment be thorough and the application even, if best results are to be secured. For small operations the ordinary orchard sprayer may be used with one or more lines of hose equipped with nozzles of the Vermorel or Bordeaux type. In case large shade trees on valuable park or woodland are to be treated, however, the use of a high-power sprayer is more economical. The type that has given the most satisfactory results in the gipsy-moth work develops sufficient power to throw a solid stream of spray into the trees. The nozzle is constructed so that the stream will break into a fine mist high in the air, and this results in very satisfactory and rapid treatment. (See fig. 11.) With such a sprayer it



FIG. 9.—Applying tree-banding material to protect the foliage from gipsy-moth caterpillars.

is unnecessary to climb trees and use small lines of hose, which is a slow and expensive operation. A satisfactory high-power sprayer (Fig. 10) for this work should be equipped with a 10-horsepower gasoline engine and a triplex pump capable of delivering 35 gallons of liquid per minute at a pressure of from 225 to 350 pounds. This machinery, together with a 400-gallon tank, should be mounted on well-built trucks. One-inch hose is used, and by slightly increasing the pressure at the machine the spray material can be conducted through several hundred feet of this hose with the outfit mentioned without seriously reducing the nozzle pressure, which should be maintained at about 225 pounds.

By using a small device, which is attached to the nozzle and is known as a spreader, it is possible to spray low growth very satisfactorily. Fruit trees can be treated very rapidly in this way (Fig. 12).

HAND METHODS TO BE USED AGAINST THE GIPSY MOTH IN ORCHARDS.

The methods to be used for controlling the gipsy moth in orchards should be determined largely by the severity of the infestation. If only a few egg clusters are present in the orchard, early spraying, such as is applied for the codling moth after the blossoms have fallen, will be found useful, providing the amount of poison used is increased to 10 pounds to 100 gallons of water. If the infestation is more serious, a second spraying early in June, using a similar amount of poison, will be found very satisfactory. In cases where the infestation is severe it probably will be necessary to creosote egg clusters in the winter and



FIG. 10.—High-power sprayer.

spray in the spring if the insect is to be controlled. In any case thoroughness is a prime essential if good results are to be secured.

All poor or hollow trees should be removed, and if badly infested woodland is near by, the orchard trees should be banded with the sticky substance previously mentioned or with the new tree-banding

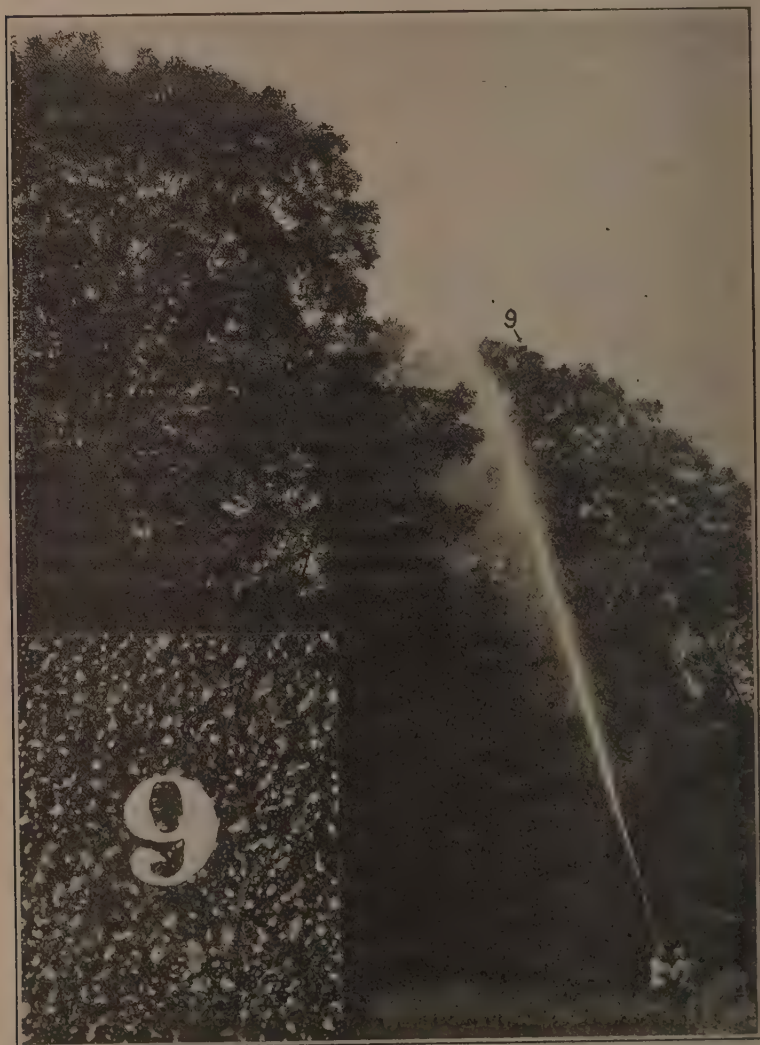


FIG. 11.—Spraying trees 35 feet high with high-power sprayer. Note thorough distribution of poison on plate (9) located at top of tree. (Worthley.)

material referred to on pages 16 and 17. Orchard infestations can be managed by following up these methods, and it will not require much additional expense or a great deal of extra work to protect the trees. In making this statement it is assumed that the orchard is being cared for by up-to-date methods for protection from the codling moth and other injurious insects and diseases, and it is improbable that these results can be brought about in neglected orchards or where the owners do not practice the best horticultural methods in handling their growing trees.

HAND METHODS FOR CONTROLLING THE GIPSY MOTH IN CITIES AND TOWNS.

The same methods that are used in orchards are applicable in cities and towns and for the treatment of park and shade trees. In certain



FIG. 12.—Spraying orchard with solid stream, using spreader. (Worthley.)

instances it probably would be advisable to use bands and to discontinue spraying, especially in cases where the infestation is light or moderate. If the infestation is bad, creosoting, banding, and spraying all should be used in their season, in order that the insect may be brought under control and the numbers present reduced to a minimum.

The proper method of handling the gipsy moth in any town, city or park, or on private estates, should be based on the infestation as determined by some one who is familiar with gipsy-moth work, if the best results are to be secured at a minimum expense. Much energy and money may be wasted in applying remedies unless their application is based on a thorough knowledge of existing conditions. An owner of an infested estate should have an examination made by some qualified person who can give reliable recommendations as to treatment. It should be borne in mind that conditions as to infestation vary from year to year, and this should be considered when plans for treatment are being made.

METHODS OF CONTROLLING THE GIPSY MOTH IN WOODLAND.

Satisfactory control of the gipsy moth in woodland by the employment of hand methods such as already have been mentioned is entirely impracticable unless the tree growth is particularly valued for purposes other than lumber. If the woodland is situated near a large city and occupies space that is likely to be utilized in a few years for building lots, considerable money may be expended to advantage in protecting the trees, as these will make the property much more valuable when the land is subdivided. Limited areas of woodland on private estates may be of sufficient value to the owners to justify a considerable expenditure for moth destruction. In all cases, however, the species of trees involved should be studied carefully before a plan of work is adopted in order that the expense may be reduced as much as possible. Unfortunately the difficulty of treating the woodlands in the infested area of New England is considerably increased by the fact that they are for the most part composed of a variety of species in mixture.

Experiments have shown that coniferous trees are not injured by the gipsy moth if grown in isolated pure stands, and if the growth is such that the trees can be thinned to a stand of conifers no hand suppressive measures are necessary in order to prevent injury by this insect. (See fig. 13.) Such lots will also be immune from attack by the brown-tail moth, as the larvæ of this insect do not feed on conifers.

If mixtures containing a large percentage of deciduous trees are to be protected from moth injury, it is very necessary that the species involved should be considered carefully before a decision is reached as to the best methods of treatment. Sometimes practical methods of thinning can be adopted so that tree species will be left that are only slightly subject to injury by these insects. A limited number of experiments have shown that mixtures of chestnut, pine, red maple, ash, and hickory, regardless of the proportion of each species, are seldom injured by the gipsy moth.

In woodlands the oaks are the most favored food plant of this insect, and unfortunately the infested region abounds in large areas where these species predominate. At present there seems to be no means aside from hand treatment which will prevent serious injury to oak woodland, but as a large part of such land consists of poor sprout growth the amount of damage sustained is not always so great as it might at first appear. The greatest injury likely to be caused in such areas where oaks and gray birch abound is the dying of small seedlings of pine or other valuable species which have been denuded by the caterpillars after the oaks and birches have been defoliated. This leaves the prospective woodland in a much worse condition than it was before the defoliation took place and reduce

greatly the chance that the sprout growth will be replaced by any species of value that can withstand gipsy-moth attack. This problem



FIG. 13.—Solid white-pine block near Nashua, N. H.: Small trees in foreground were transplanted some years ago. The foliage of this species is not attacked by *small* gipsy-moth larvæ, so it is not injured if grown in clean stands.

is being specially studied and considered in the hope that some economical method may be devised for protecting and improving

woodlots of this character at moderate expense. It is true that in considerable areas of oak woodland the trees, although not mature, could be utilized for small timber, railroad ties, or cordwood, and in cases of bad infestation such woodland should be cut promptly if the wood can be sold to advantage. On cheap cut-over or infested lands in many sections of the territory planting of white pine might be done to advantage, but as this involves considerable expense and as the future crop can not be harvested for a period of years, the question as to the desirability of managing any woodlot in this way must in the end be decided by the owner of the property.

The presence of the chestnut-bark disease or the white-pine blister rust in a locality should receive due consideration before plans are made for planting or encouraging the growth of either of these species.

If the practice common in some European countries of maintaining municipal or State forests were well developed in the New England States, it would be possible in a period of years to transform considerable areas of land which are now destined to be worthless, and which form a favorable feeding ground for the gipsy moth, into well-managed forests of valuable growth.

METHODS OF CONTROLLING THE BROWN-TAIL MOTH IN WOODLAND.

The damage caused by the brown-tail moth ordinarily is not so severe as is that resulting from gipsy-moth infestation because the former species does not have so wide a range of food plants and, further, because the bulk of the feeding is done early in the season so that the trees have an opportunity to recover before midsummer. In the territory where both insects exist the caterpillars of the gipsy moth supplement the work which is done by those of the brown-tail moth and the injury, therefore, is increased greatly. The large areas of oak-sprout growth furnish abundant food for brown-tail moth caterpillars, and as a result enormous numbers of the moths develop which migrate each season to the cities and towns and render it necessary for hand suppressive measures to be put in force each year. The area reinfested in this way depends largely on the prevailing winds during the month of July when the moths are flying. Elimination of oak, scrub apple, and wild-cherry trees would assist greatly in reducing the numbers of this pest.

STATE WORK AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

Each of the New England States is carrying on work for the control of these insects. The organization varies because of local conditions, but the same general methods of field work are employed.

In Maine the work is in charge of the commissioner of agriculture, who has authority to appoint a superintendent of moth work. The southwestern portion of the State is from generally to badly infested with the gipsy moth, while in the outlying area only scattering infestations have been found. The brown-tail moth usually is most abundant along the coast or near the main water courses. Seven thousand six hundred and fourteen square miles in this State are infested with the gipsy moth and 16,783 square miles with the brown-tail moth.

In New Hampshire the moth work is in charge of the State entomologist. Five thousand nine hundred and twenty square miles are infested with the gipsy moth and 8,113 square miles with the brown-tail moth. The heaviest gipsy-moth infestations in the State are south of Lake Winnepesaukee, although extensive infested areas occur west of the Merrimac River.

In Vermont the moth work is in charge of the commissioner of agriculture, who appoints a deputy to carry on the field work. Only one town in this State has a gipsy-moth infestation and this consists of a few eggs clusters which have been treated and the locality cared for by employees of the Bureau of Entomology. The whole area known to be infested by the brown-tail moth amounts to 2,666 square miles, but the infestation is very light and in many of the towns within this area it is very difficult to find this insect.

The State forester has charge of the moth work in Massachusetts. Each infested town is required by law to select a local superintendent, whose appointment must be approved by the State forester. Owners are required by law to keep their property free from these pests, but can not be compelled to expend for this purpose more than \$5 on each \$1,000 assessed valuation. Town and city appropriations are made to give proper treatment to the street trees and those in public parks, and if sufficient funds are not available to do the work properly, financial aid is given by the State. The gipsy moth infested area in Massachusetts covers 4,980 square miles and 6,115 square miles are infested to a greater or less extent by the brown-tail moth.

The moth work in Rhode Island is in charge of the State board of agriculture and is placed by it under the supervision of the State entomologist. Every town in the State is infested with both of these pests. The insects are most abundant in the northern part of the State and in the territory immediately surrounding Providence.

In Connecticut the work is in charge of the State entomologist. The brown-tail moth infestation covers 1,993 square miles and the gipsy-moth infestation 639 square miles. There is great danger that the gipsy moth will spread rapidly in this State, owing to the fact that

the oak, which is a food plant favored by this insect, is one of the predominating trees.

The small colony of the gipsy moth which was found in Geneva, N. Y., in 1912 has been exterminated. Effective work was done by the State department of agriculture, and several inspections of the colony and its surroundings have been made by employees of the Bureau of Entomology. The colony located at Mount Kisco, Westchester County, N. Y., in May, 1914, has been treated thoroughly and no egg clusters have been found during the past year. Persistent work has been done in an attempt to stamp out this colony, both by the State and by the Bureau of Entomology, and it is hoped that this may be accomplished after another season's work.

In February, 1914, a colony was reported on an estate at Bratenahl, near Cleveland, Ohio. The territory was scouted thoroughly by employees of the Bureau of Entomology and treatment applied by the State nursery inspector. No infestation has been found in the colony or its surroundings for more than a year, and it is believed that the insect is exterminated.

A small colony was found at Rutherford, N. J., in July, 1914. It has received careful attention and as a result of the work done has been exterminated.

WORK CARRIED ON BY THE BUREAU OF ENTOMOLOGY.

The work carried on by the Bureau of Entomology of the United States Department of Agriculture is designed to prevent the spread of these insects.

Owing to the freedom with which the female brown-tail moth flies it is difficult by hand measures to prevent the spread of this species, as a heavy migration may take place into new territory during any year when the wind is favorable at the time the moths are flying.

The spread of the gipsy moth has been much slower. All the principal infestations found in new territory have been along the line of the winds prevailing when the gipsy-moth caterpillars are hatching in the spring. The greatest danger of spread is toward the north and northeast, as the warm winds in the spring, particularly along the coast, are from the south and southwest. In New Hampshire, between the Merrimac and Connecticut Rivers, and in the infested region south of it, extending through Massachusetts, Rhode Island, and Connecticut to Long Island Sound, the problem of wind spread has the greatest bearing on the further dispersion of the gipsy moth. Scouting and extermination work is carried on extensively in this region under the direction of Mr. L. H. Worthley and every effort is being made not only to determine whether infestations exist in the new territory, but to exterminate the insects in several tiers of

towns adjoining the border in order that wind spread into the territory that already has been treated may be prevented.

In town or city work the bureau advises that careful attention be given to woodland infestation or isolated trees, particularly if they are located on high elevations immediately outside the residential area, as such colonies may furnish a supply of caterpillars which will be distributed throughout the town after it has been cleaned.

Under present conditions, owing to the decrease in the severity of gipsy-moth infestation in most sections, spraying becomes an economical means of treatment and in some cases is used exclusively for control.

A great amount of experimental work has been conducted in order that better methods of controlling these insects may be determined. The introduction of natural enemies from Europe and Japan has proceeded systematically and good results are being noted in many localities. A systematic study of the wilt disease, which attacks gipsy-moth caterpillars in the field, is being made in cooperation with the Bussey Institution of Harvard University. Silvicultural investigations, which have for their purpose the adoption of better methods of forest management which will assist in the control of these pests, are being carried on in cooperation with the Forest Service of this department. This work is conducted by Mr. George E. Clement.

The entire infested area—20,211 square miles occupied by the gipsy moth and 36,684 square miles occupied by the brown-tail moth—has been placed under quarantine by the Federal Horticultural Board, and shipments of nursery stock, lumber, cordwood, and other forest products and stone and quarry products are not permitted to leave the territory unless they have been inspected and are accompanied by a certificate stating that they are free from infestation. This work is designed to prevent the spread of the insects for long distances and is being administered by Mr. D. M. Rogers.

COOPERATIVE WORK.

Since the gipsy moth and brown-tail moth work was started by the Bureau of Entomology more or less cooperative work has been carried on with the States concerned. The introduction of parasites and natural enemies of the gipsy moth was conducted cooperatively with the State of Massachusetts for several years. After the infestation covered large areas in other States an arrangement was made for this work to be carried on by the Bureau of Entomology. The general plan of field work is for the bureau to handle the territory embracing several tiers of towns along the outside border of gipsy-moth infestation, while the States manage the work inside this area. The quarantine covers the entire infested area, while the experimental work, including the colonization of parasites, is being

carried out in a systematic way for the purpose of developing better methods for the use of all concerned and to bring about the dispersion of the various parasites over the entire infested area as rapidly as possible.

THE OUTLOOK.

Infestation by the brown-tail moth is less severe than it has been for a number of years. A marked reduction in the number of winter webs has been noted, and if natural enemies continue as effective as they are at present, this insect can be controlled with small expense. At the present time, however, there is no way of telling exactly what will happen in this respect, and a careful record is being kept as to the abundance of this insect so that more work can be done upon it if the effectiveness of natural enemies should be suddenly reduced.

The gipsy-moth infestations have been reduced considerably during the last few years. The territory infested has remained practically the same and the improved methods which have been employed have shown good results. The great danger that widespread infestation will be brought about by wind drift of the small caterpillars can not be ignored and every effort is being made to restrict this danger as much as possible. When parasites are becoming more effective, and the increase of the gipsy moth in the field is slow, is the proper time to exert every effort to reduce further the abundance of the insect and so far as possible decrease the area infested.

